

Exotic narrow resonance searches in the systems $K_s^0 p$, $K_s^0 \Lambda$ and Λp in pA-interactions at 10 GeV/c

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Abstract

Experimental data from the 2m propane bubble chamber have been analyzed to search for an exotic baryon states, in the $K_s^0 p$, $K_s^0 \Lambda$ and Λp decay mode for the reaction $p + C_3H_8$ at 10 GeV/c.

The invariant mass spectrum ΛK_s^0 observe a narrow peaks at 1750, 1795, 1850 MeV/ c^2 . The statistical significance of these peaks has been estimated as 5.6, 3.3 and 3.0 S.D., respectively. There are the small enhancements in mass regions of (1650-1675) and (1925-1950) MeV/ c^2 . These would be candidates for the N^0 or the Ξ^0 pentaquark states.

The $p K_s^0$ invariant mass spectrum shows resonant structures with $M_{K_s^0 p} = 1540, 1613, 1821$ MeV/ c^2 . The statistical significance of these peaks have been estimated as 5.5, 4.8 and 5.0 s.d., respectively. There are also small peaks in 1487(3 s.d.), 1690(3.6 s.d.), 1750(2.3 s.d.) and 1980(3.0 s.d.) MeV/ c^2 mass regions.

The invariant mass spectrum $S=-1 \Lambda p$ observe a narrow peaks at 2100, 2175, 2285 and 2353 MeV/ c^2 . Their excess above background by the second method is 6.9, 4.9, 3.8 and 2.9 S.D., respectively. There is also a small peak in 2225(2.2 s.d.) MeV/ c^2 mass region.

The investigation has been performed at the Veksler and Baldin Laboratory of High Energies, JINR.

1 introduction

Multi-quark states, glueballs and hybrids have been searched for experimentally for a very long time, but none is established. Several models ([1]-[5]) predict the multiplet structure and characteristics of multi quark hadrons and pentaquarks for example the chiral soliton model, the uncorrelated quark model, correlated quark models, QCD sum rules, thermal models, lattice QCD

Results from a wide range of recent experiments[6, 7] are consistent with the existence of an exotic $S=+1$ resonance, the $\Theta^+(1540)$ with a narrow width and a mass near 1540 MeV cite1.

Preliminary results on a search for the Ξ^0 $I=1/2$ as well as for the N^0 or the Ξ^0 pentaquark states in the decay mode ΛK_s^0 with the mass $1734 \pm 0.5 \pm 5$ MeV/ c^2 is presented in the article[8]. A narrow resonance significant signal for $\Xi^0(1750) \rightarrow \Xi^- \pi^+$ and $N^0(1680) \rightarrow N \pi$ were observed in [9, 10].

Metastable strange dibaryons were searched a long time ago at LHE JINR, too. The effective mass spectra of 17 strange multiquark systems were studied. Our group succeeded in finding resonance-like peaks [11, 12] only in five of them Λp , $\Lambda p \pi$, $\Lambda \Lambda$, $\Lambda \Lambda p$, $\Lambda \pi^+ \pi^+$.

2 Experiment

The JINR 2m bubble chamber is the most suitable instrument for this purpose [7, 13]. The experimental information of more than 700000 stereo photographs are used to select the events

with V^0 strange particles. The effective mass distribution of 8657-events with Λ , 4122-events with K_s^0 particles are consistent with their PDG values [7, 13]. The effective mass resolution of ΛK_s^0 system was estimated to be on the average 1%. The effective mass resolution for systems from $K_s^0 p$ and Λp combinations were estimated to be 0.6 % for protons over the following momentum range: $0.150 \leq p \leq 0.900$ GeV/c.

3 $pK_s^0, \Lambda K_s^0$ and Λp spectrum analysis

The total experimental background has been obtained by three methods [7, 13, 14]. In the first method, the experimental effective mass distribution was approximated by the polynomial function after cutting out the resonance ranges because this procedure has to provide the fit with $\chi^2=1$ and polynomial coefficient with errors less than 30 %. The second of the randomly mixing method of the angle between of decaying particles from the resonance for experimental events is described in [17]. Then, these background events were analyzed by using the same experimental condition. The third background method has been obtained by using FRITIOF model ([18]) with experimental conditions. The analysis done by three methods has shown that while fitting these distributions had the same coefficients and order of polynomial. The values for the mean position of the peak and the width obtained by using Breit Wigner fits.

3.1 pK_s^0 - spectrum for protons with a momentum of $0.350 \leq p_p \leq 0.900$ GeV/c

The pK_s^0 effective mass distribution 2300 combination (Fig.1a) is shown resonant structures with $M_{K_s^0 p}=1540, 1613, 1821$ MeV/ c^2 and $\Gamma_{K_s^0 p}= 9.2, 16.1, 28.0$ MeV/ c^2 ([7]). The statistical significance of these peaks have been estimated as 5.5, 4.8 and 5.0 s.d., respectively. There are also small peaks in 1690(3.6 s.d.), 1750 (2.3 s.d.) and 1980(3.0 s.d.) MeV/ c^2 mass regions.

3.2 ΛK_s^0 - spectrum analysis

Figure 1b shows the invariant mass of 1012 (ΛK_s^0) combinations with bin sizes 10 MeV/ c^2 ([13]). There are significant enhancements in mass regions of 1750, 1795 and 1850 MeV/ c^2 (Fig.1b). Their excess above background by the first method is 5.0, 2.7 , 3.0 S.D.. There are small enhancement in mass regions of 1670 and 1935 MeV/ c^2 .

3.3 Λp - spectrum analysis for protons with a momentum of $0.250 \leq p_p \leq 0.900$ GeV/c

Figure 1c shows the invariant mass of 2434 (Λp) combinations with bin sizes 15 MeV/ c^2 ([12]). The values for the mean position of the peak and the width obtained by using Breit Wigner fits. There are significant enhancements in mass regions of 2100, 2175, 2285 and 2353 MeV/ c^2 (Fig.1c). Their excess above background by the second method is 6.9, 4.9, 3.8 and 2.9 S.D., respectively. There is also a small peak in 2225(2.2 s.d.) MeV/ c^2 mass region.

4 Conclusion

A number of peculiarities were found in the effective mass spectrum of: $K_s^0 p$ in regions of 1487, 1540, 1685, 1750, 1821 and 1980 MeV/ c^2 : ΛK_s^0 in regions of 1670, 1750, 1785, 1850 and 1935

MeV/ c^2 ; Λp in regions of 2100, 2175, 2225, 2285 and 2353 MeV/ c^2 .

These peaks in the effective mass spectrum ΛK_s^0 are possible candidates for two pentaquark states: the N0 with quark content udsds decaying into ΛK^0 and the Ξ^0 quark content udssd decaying into $\Lambda \bar{K}^0$, which are agreed: with the calculated rotational spectra N0 and Ξ^0 spectra from the theoretical report of D. Akers [5], A.A. Arkhipov [16] and with Θ^+ spectra from the experimental reports of Yu.A. Troyan [15] and P. Aslanyan [7].

The experimental result for S=-1 Λp dibaryon spectrum shows that the predicted peaks with the bag model has been confirmed [12].

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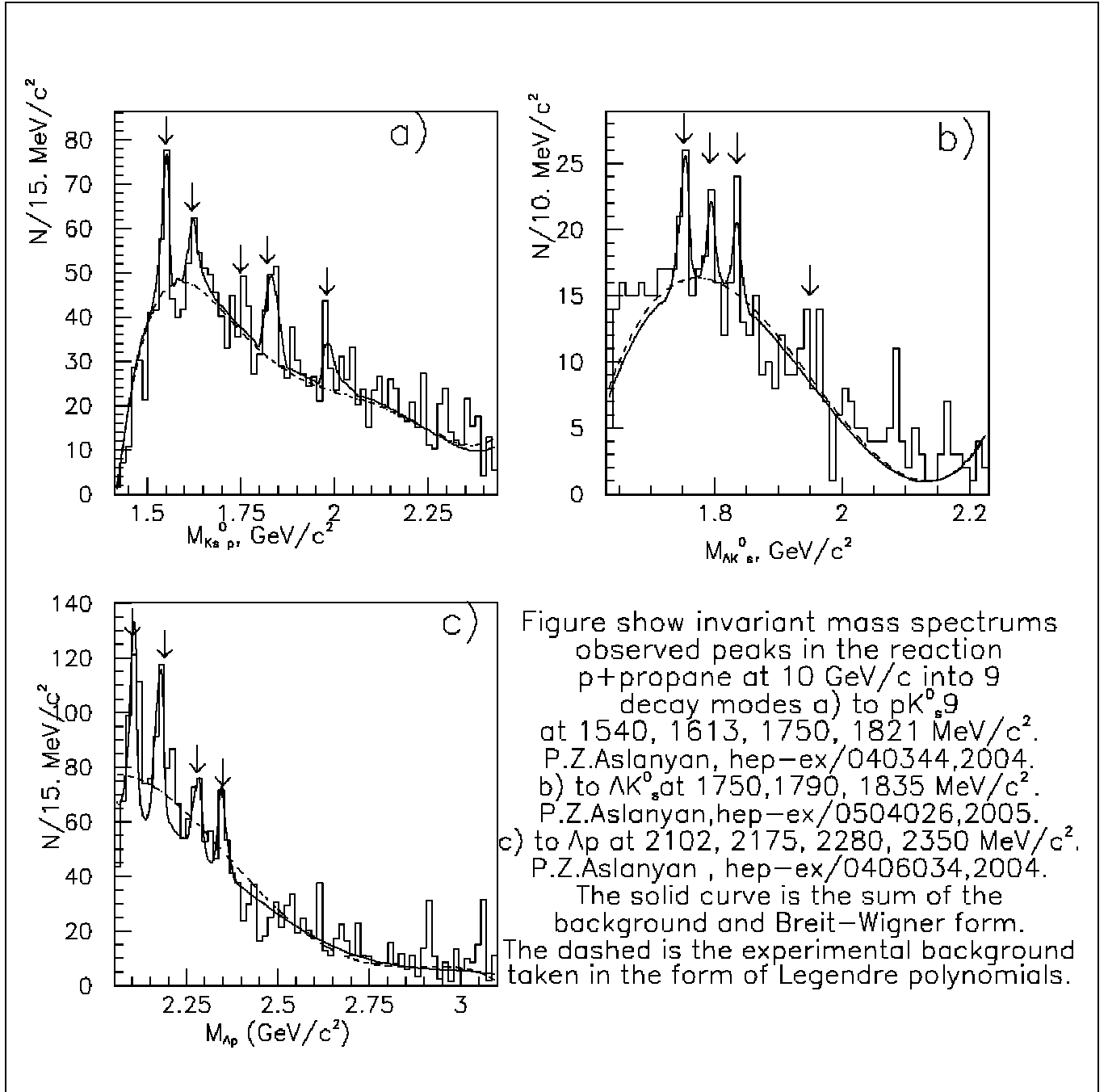


Figure 1: The effective mass distribution for systems: (a) pK_s^0 , (b) ΛK_s^0 and (c) Λp .